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Hudson Bay and Ungava Bay Ice-Melt Cycles for the Period 1963–1983

R.H. Loucks and R.E. Smith

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ABSTRACT

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There is potential for significant oceanographic effects due to large discharge of freshwater from Hudson Strait. Freshwater discharge arises both from land runoff and ice-melt. To investigate possible effects, a long time series of freshwater discharge would be desirable. In a previous report, such a time series was compiled for runoff based on river gauging data. In this report a similar time series for ice-melt is derived based on weekly ice thickness observations at a network of stations in Hudson Bay, James Bay, Foxe Basin and Hudson Strait.

RÉSUMÉ

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Il est possible que la présence d'un vaste débit d'eau douce provenant du détroit d'Hudson ait des effets océanographiques importants. Le phénomène est causé à la fois par l'écoulement terrestre et par la fonte des glaces. Pour étudier ses effets possibles, il serait souhaitable de disposer d'une longue série chronologique sur ces écoulements d'eau douce. Dans un rapport antérieur on a compilé une série chronologique de cette nature d'après des données provenant du jaugeage des rivières. On cherche ice à établir une série semblable pour les eaux de fonte des glaces, en se fondant sur les observations hebdomadaires de l'épaisseur de la glace réalisées par un réseau de stations de la baie d'Hudson, de la baie James, du bassin Foxe et du détroit d'Hudson.

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Table A.1 Maximum ice thickness (augmented by 10% of snow cover) and corresponding date, date of open water and representative decay time constants for each station by year.

1.0 Introduction

The river runoff discharging through Hudson Strait between 1963 and 1983 has previously been calculated (Prinsenberg et al.1987; hereafter referred to as A) using three drift speed scenarios. The important freshwater contribution from ice melt to the freshwater budget remains to be treated. The purpose of this report is to assemble monthly and annual time series of ice volumes and ice melt discharges for Hudson Bay, James Bay, Foxe Basin, Hudson Strait and Ungava Bay for the period between 1963 and 1983. Sub-area ice-melt discharges are combined to estimate ice-melt discharge through Hudson Strait. Three ocean drift speed scenarios are again used to simulate the transport of the melt water from each area toward the entrance to Hudson Strait. It is assumed that the melt water leaves Hudson Strait in a low-salinity surface layer. The question of the salt balance is not addressed here.

2.0 Derivation of Ice-melt Volumes

2.1 Plots of Ice Thickness Time Series

A computer tape containing observations as frequent as once per week of ice and snow thickness data during the period of interest (1963-1983) was obtained from Ice Centre, Environment Canada, Ice Climatology and Applications Division, Ottawa. From a chart of Ice Thickness Monitoring Stations (Figure 1), stations were selected in Hudson Bay (Chesterfield Inlet, Churchill, Kumjjuarapik [Poste de la Baleine], Inukjuac, and Coral Harbour); in James Bay (Moosonee); in Hudson Strait (Cape Dorset, Koartaq and Iqaluit [Frobisher Bay]); in Ungava Bay (Kumjjuaq [Fort Chimo]); and in Foxe Basin (Hall Beach), to represent the ice-volume subareas (Figure 2). The data from these eleven stations are plotted (Figures 3 to 13).

2.2 Identification of Maximum Thickness and Melt Season by Year

The period of record was identified for each station (Table 1). Then the maximum thickness of ice (plus 10% of the snow depth) in centimetres and the corresponding time in Julian days as well as the time of open water were identified for each year. These are recorded in Table 2.

The ice thickness observations are made near shore. It is assumed that landfast and offshore ice thicknesses are equal. This appears to be a reasonable assumption for land-locked ice such as found in our study area and observed during winter temperature-salinity profile

surveys done in James Bay and Southeastern Hudson Bay during which holes were drilled through the offshore pack-ice. However, a recent study on the ice volume and frequency of ice ridges for the area (Prinsenberg, 1988) indicates that a large amount of additional ice is present in ice ridges above that accounted for by local offshore ice. The present calculations do not take this into account but future calculat ions will do so when additional ridge statistics become available.

The maximum thickness of ice and snow and the corresponding time were recorded and available with few exceptions. However, for most stations the time of open water was usually missing in the recent years of record (1980-). Since it was never possible to hindcast the time of open water by correlating with either the maximum thickness or its corresponding time or with the time of open water from a neighbouring station (either because correlations were very low or data were unavailable), an average value was calculated for the particular station and used in place of the missing time of open water. Another approach would have been to adopt an average duration of melt season and then to approximate the time of open water as the average lag after time of maximum thickness. In most cases, the range of times of open water within the record fell within the one-month temporal resolution of this analysis. However, this use of the average sacrifices some inter-annual variability.

Individual treatment of each station is documented in Appendix A.

2.3 Identification of Month-end Thickness through the Melt Season

To calculate the monthly rate of ice melt one requires the ice thickness at the end of each month. Where data were plentiful throughout the melt period, linear interpolation was used to arrive at ice thickness values for the last day of each month.

Where data were scarce throughout the melt season, an exponential decay model (Billelo,1980) for melt was least-sqauares fitted for the particular station to arrive at ice thickness values for the last day of each month.

$$T(t) = \frac{T_{max}(e^{Rto} - e^{Rt})}{(e^{Rto} - 1)}$$

where T(t) is ice thickness at time,t; T_{max} is maximum thickness observed (at t = 0); t_o is the time of open water; and R^{-1} is the time constant of ice-melt. The model requires that a representative time constant be calculated from years with plentiful data for the particular station.

The month-end thickness data for the four stations representing Hudson Strait (Cape Dorset, Koartaq, Iqaluit and Kumjjuaq) were (weighted-)averaged into a single signal.

2.4 Incomplete Records

When there were no observations in a particular year, maximum thickness and its time of occurrence were hindcast by regressing maximum thickness and corresponding time from a neighbouring station for a period when data were available for both stations. For the time of open water the average value was used. The average time constant already calculated for the station in question was then used in the exponential model to interpolate for month-end ice volumes.

2.5 Conversion of Month-end Thickness Data to Monthly Volume Discharge for the Sub-Area

Monthly melt data were obtained, starting with the month of maximum thickness, by subtracting the month-end thickness from the maximum thickness, then differencing successive month-end thicknesses up to and including the month of open water.

The monthly melt data (thickness melted) for each station was multiplied by the area of ice surface which each station represented to produce monthly ice-melt discharges. Area estimates from Prinsenberg (1977) were used (Table 2).

2.6 Results

The exponential ice decay model fitted the data well.

The monthly melt discharges (m^3/s) for level sea ice corrected to freshwater equivalent by discounting the typical 0.5% salt content, are shown for each subarea in Tables 3 to 10. The annual average discharge, shown in the last column, is proportional to the maximum ice thickness for that particular year.

The ice-melt season is compressed into two or three months. On an annual basis, ice discharges are less than runoff in James Bay (A) but exceed runoff in the other subareas. The month of peak discharge occurs later for both runoff and ice melt as one proceeds northward. These peaks often occur in the same month in a particular region. However in SE Hudson Bay peak ice melt occurs in May while peak runoff occurs in June.

The estimated errors for these discharges consist simply of the uncertainties in measurement and in extrapolation from one or a few observing stations over the whole subarea. The experience in Hudson Bay is that ice thickness tends to be quite uniform. It is assumed

that errors are random and that they amount to 15% (standard deviation) of the discharge in each case. In previous work on runoff (A), it was found that for combined Hudson Strait discharge, timing uncertainties were more critical than measurement and extrapolation errors. These are discussed below.

3.0 Combined Ice-Melt Discharges Through the Entrance to Hudson Strait

3.1 Procedure

Combined ice-melt discharges leaving Hudson Strait were estimated by considering the drift speed/time from each subarea. The combined discharge for e.g. July, 1970, was calculated as the sum of the discharge for NW Hudson Bay at an appropriate earlier month plus the discharge for SW Hudson Bay for, again, an appropriate earlier month, and so on. Two drift scenarios were established in A, in addition to the zero drift case, to provide these lag times. The lag times are shown in Table 2.

3.2 Results

The combined, lagged and drifted ice-melt discharges leaving Hudson Strait are shown in Table 11 for the zero-drift case, in Table 12 for the base drift scenario, and in Table 13 for the fast drift scenario. The over-all average ice-melt discharge is 2.4 times the overall average runoff discharge. In the base drift scenario, on average, the major ice-melt discharge is compressed into a three-month season centred on August (Figure 14). For the zero-drift and fast-drift scenarios, the peak ice-melt discharge is even more compressed reaching, for the latter case, an estimated 0.34 Sverdrups in July. The combined ice-melt discharge patterns from the three drift scenarios are much more alike than the two combined runoff patterns for the same drift scenarios (A).

In the base-drift scenario, the August average discharge is estimated to be 0.2 Sverdrups. This contrasts with the combined runoff discharge for this drift scenario (A); the latter exhibits several peaks (March, June, November) the highest of which (November) is estimated to be 19% of this August ice-melt discharge (but slightly larger than the November ice-melt discharge). In the fast-drift scenario, the July combined runoff discharge amounts to 11% of the (peak) July ice-melt discharge.

Inter-annual variability, expressed as the ratio of the standard deviation over the average, the coefficient

of variation, is in the range .23 to .33 over the three peak months of the ice-melt base drift scenario, and in the range .15 to .43 over the three peak months of the fast drift scenario. Figure 15 shows the interannual variability of annual ice-melt discharge.

3.3 Error Estimates

To the measurement and extrapolation errors are added, in the case of combined discharges, the errors accruing from uncertainties in the lag times. To assess this source of uncertainty, the situation where all lag times are one month too short is considered. The question is, 'What are the total uncertainties then to be associated with the combined discharges?'

There is a systematic shift which arises in increasing or decreasing all lag times by one month. This is calculable from the differences in monthly averages. The random errors merit attention. They are estimated as the standard deviation over the years of the difference in discharges - the lagged month discharge minus the previous month's discharge. As an example, if every year were average, the result of a shift in lag time would be simply systematic. The random timing errors arise because the pattern from e.g. April to May in SE Hudson Bay is not exactly repeated year-to-year.

Combined measurement, extrapolation and timing errors have been calculated for base-drift and fast-drift ice-melt discharges over the peak months. The timing errors assume a one-month shift in lag times, as mentioned. For the base-drift case, standard deviation errors, not including systematic effects, are estimated to be $\pm$40% for June, $\pm$ 44% for July and $\pm$ 36% for August; for the fast-drift scenario, $\pm$40% for June, $\pm$24% for July and $\pm$51% for August.

In overview, the standard deviation of average annual ice-melt discharge, i.e. the interannual variability of total ice volume is, from Tables 12 and 13, 7% of the grand average. Measurement and extrapolation errors, assumed to be 15% for each station/month, are contributing to this interannual variability.

In contrast, the monthly coefficents of variation, for the three peak months, for melt patterns alone (Table 11) are 21 - 35%, while for combined melt/drift scenarios they have values of 23-33% for the base drift case (Table 12) and 15-44% for the fast-drift case (Table 13).

These latter coefficients of variation are comparable to the estimated uncertainties for a 1-month shift in lags, thus supporting the conclusion that timing variability/uncertainty rather than measurement and extrapolation uncertainty, contribute most to the variability in a particular month. This uncertainty is avoided in the annual averages.

4.0 Conclusions and Recommendations

Ice-melt discharge time series for subareas have been estimated and combined, using lags, to produce oceanographic 'signals' for discharges leaving Hudson Strait. As with runoff, timing uncertainties are assessed as more critical than measurement and extrapolation uncertainties.

The subarea series peak at or near the time of spring freshet. The combined series, using either the slower 'base-drift' scenario or a fast-drift scenario, exhibit sharp peaks at nearly the same time, in August and July respectively. Thus one can be fairly certain about the timing of the peak ice-melt discharge from Hudson Strait.

The magnitude of this peak discharge is on the order of 0.2 Sverdrups and 5 to 10 times the runoff discharge for July/August. Overall average ice-melt discharge is 2.4 times overall average runoff discharge. This reflects the fact that the ice-melt discharge from Hudson Strait is compressed into a shorter season than runoff discharge.

Interannual variability on a monthly basis is, unfortunately, no larger than the estimated uncertainites i.e. the effects of timing uncertainites. Therefore comparisons with other oceanographic series will, it seems, be limited to seasonal or annual aggregates.

While we feel very fortunate to have this ice observation database, it is recommended that observers be encouraged to record the date of open water, not only for the landfast ice stations but also for the offshore regions, for melt season applications such as this.

It is recommended that these series be compared with other oceanographic series such as Station 27 salinity and with atmospheric time series such as freezing and melting degree days.

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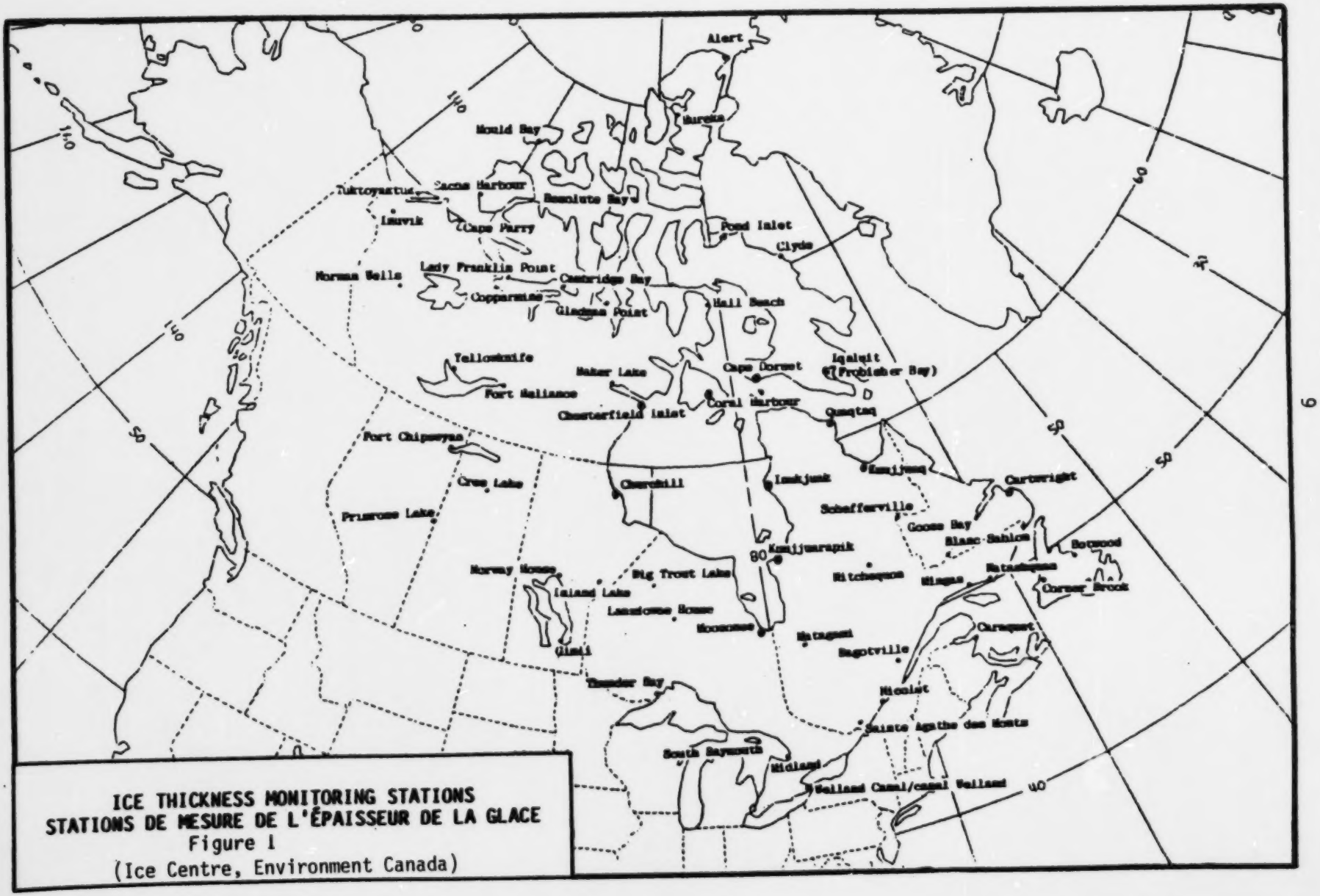
Alert
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Tuktoyaktuk
Sachs Harbour
Resolute Bay
Inuvik
Cape Parry
Pond Inlet
Clyde
Norman Wells
Lady Franklin Point
Cambridge Bay
Coppermine
Gladman Point
Hall Beach
Yellowknife
Baker Lake
Cape Dorset
Iqaluit (Frobisher Bay)
Fort Reliance
Coral Harbour
Chesterfield Inlet
Quaqtaq
Port Chipewyan
Kangiqsq
Cartwright
Cree Lake
Churchill
Inukjuak
Primrose Lake
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Norway House
Big Trout Lake
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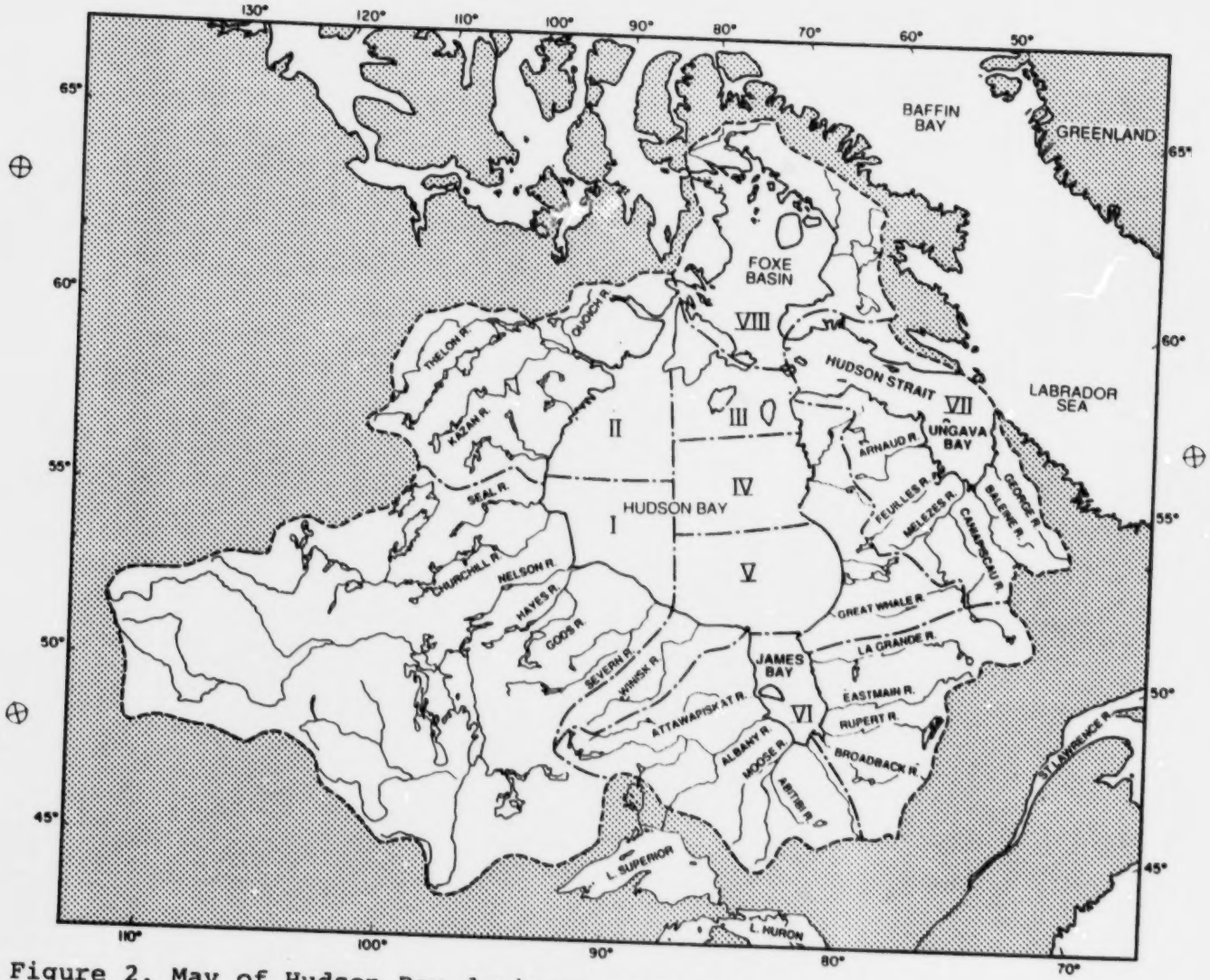

Figure 2. May of Hudson Bay drainage areas and receiving seawater regions. (Prinsenberg et al., 1987)

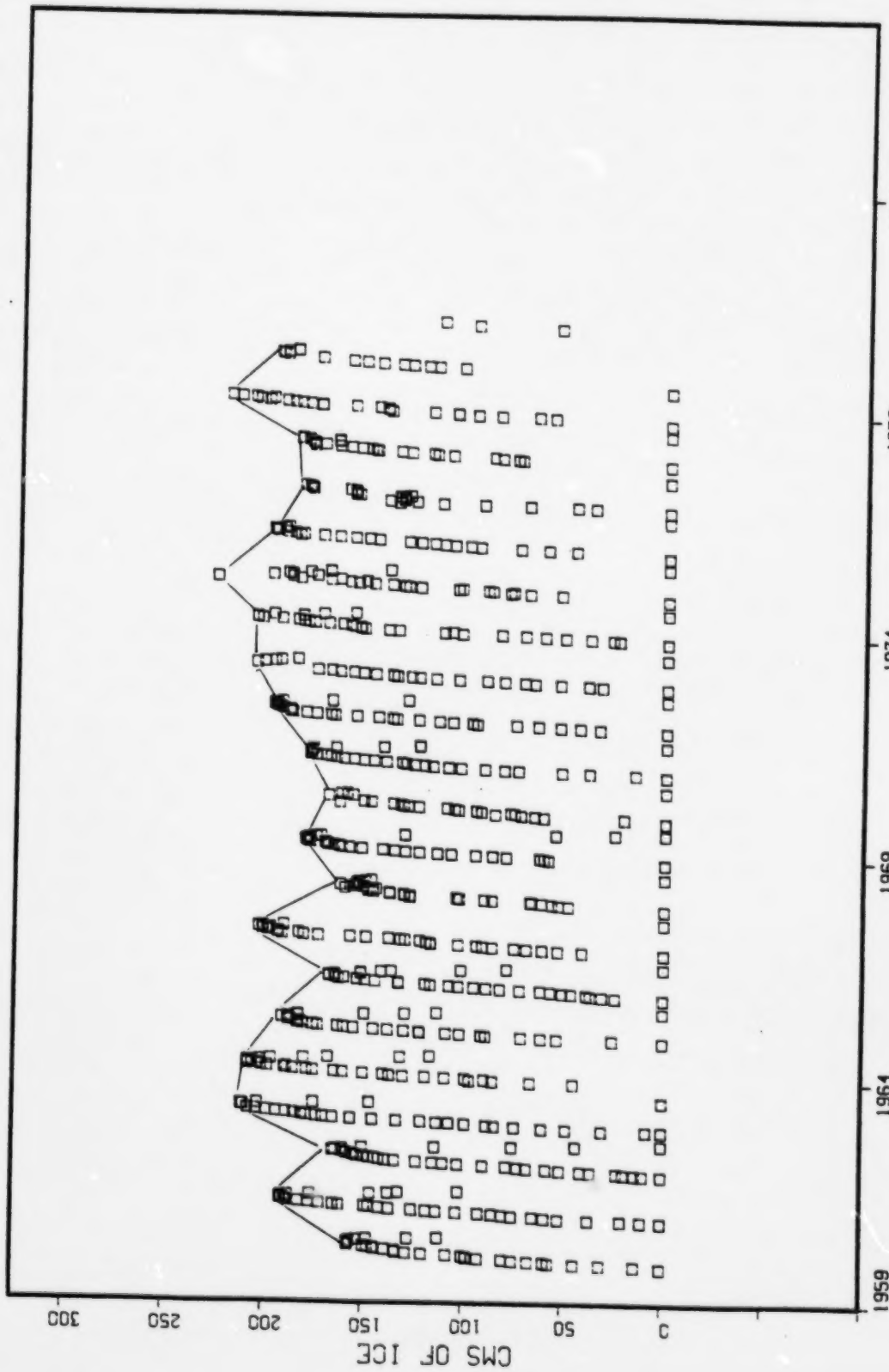

Figure 3. Time series plot of ice thickness observations,(including 10% of snow cover),Chesterfield Inlet.

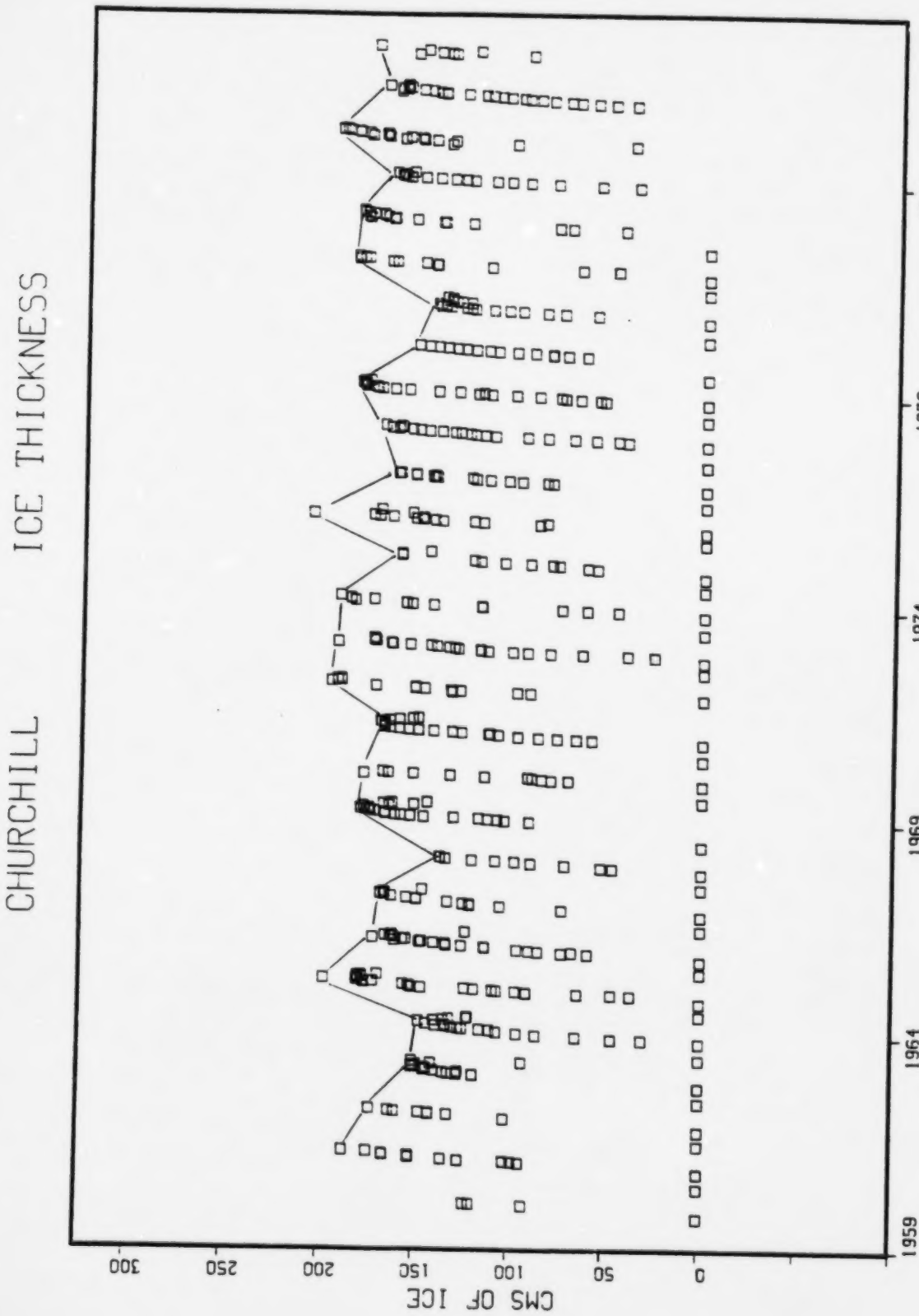

Figure 4. Time series plot of ice thickness observations (including 10% of snow cover), Churchill.

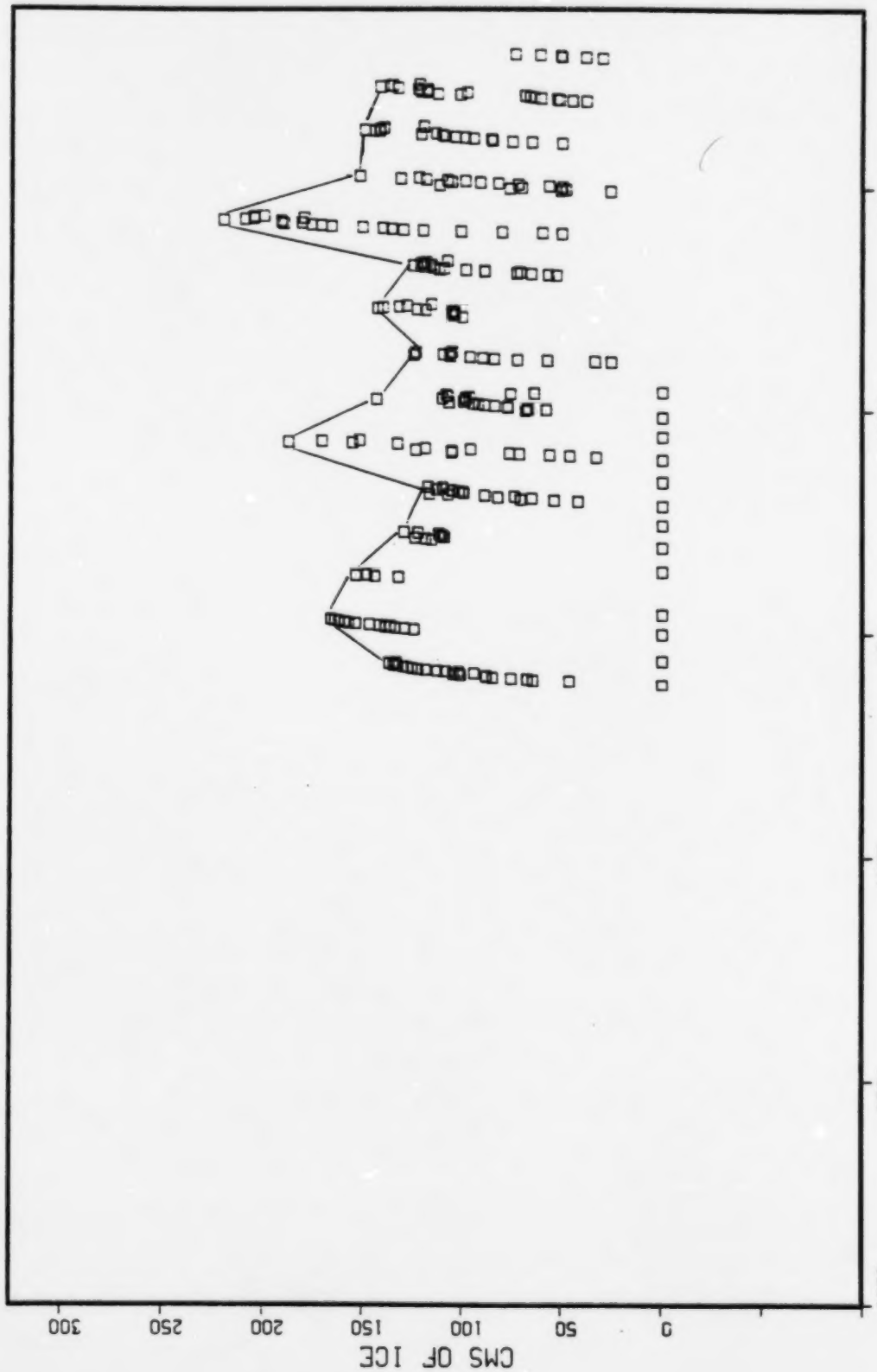

Figure 5. Time series plot of ice thickness observations (including 10% of snow cover), Kumjjuarapik.

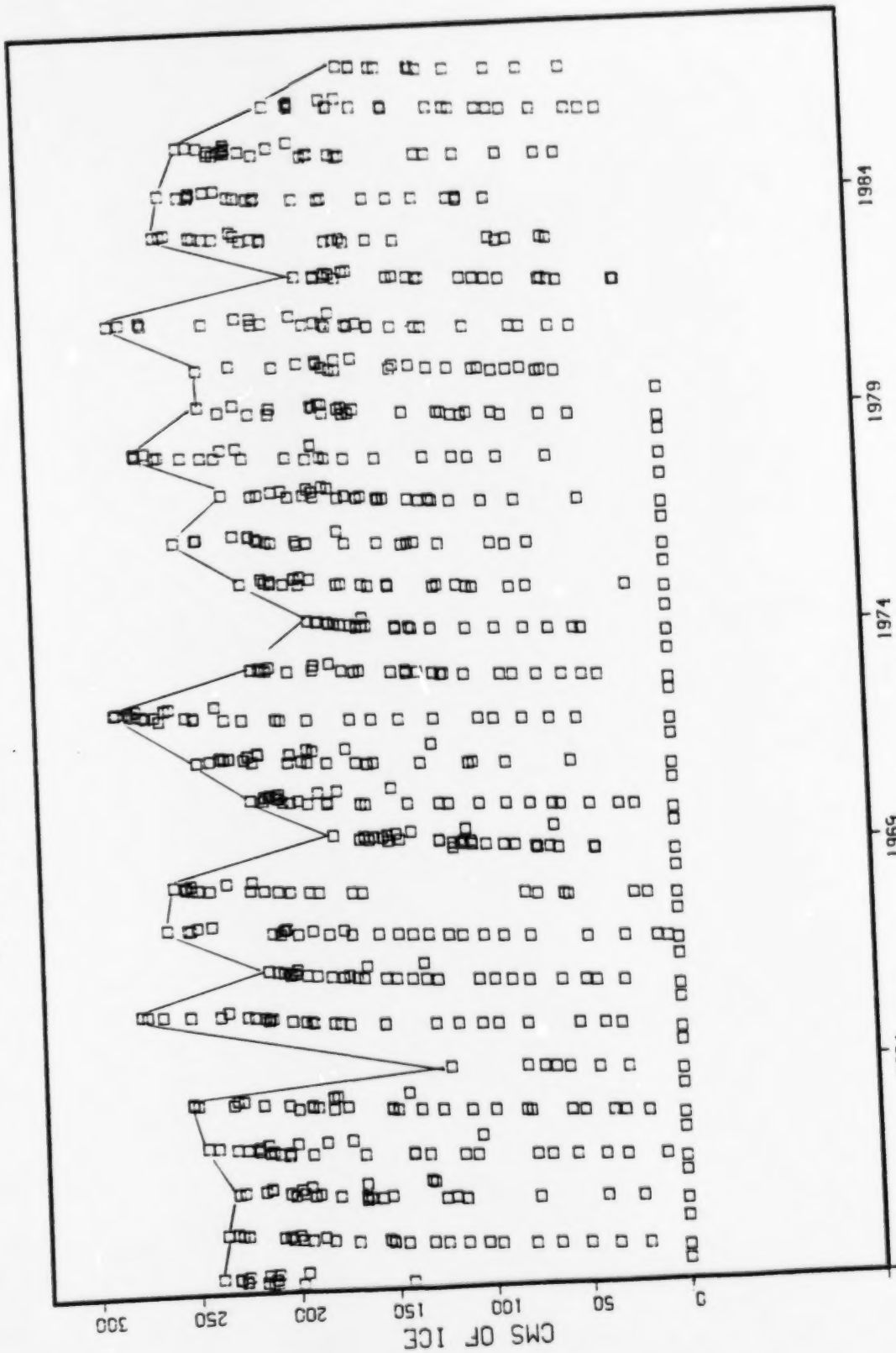

Figure 6. Time series plot of ice thickness observations (including 10 % of snow cover), Inukjouac.

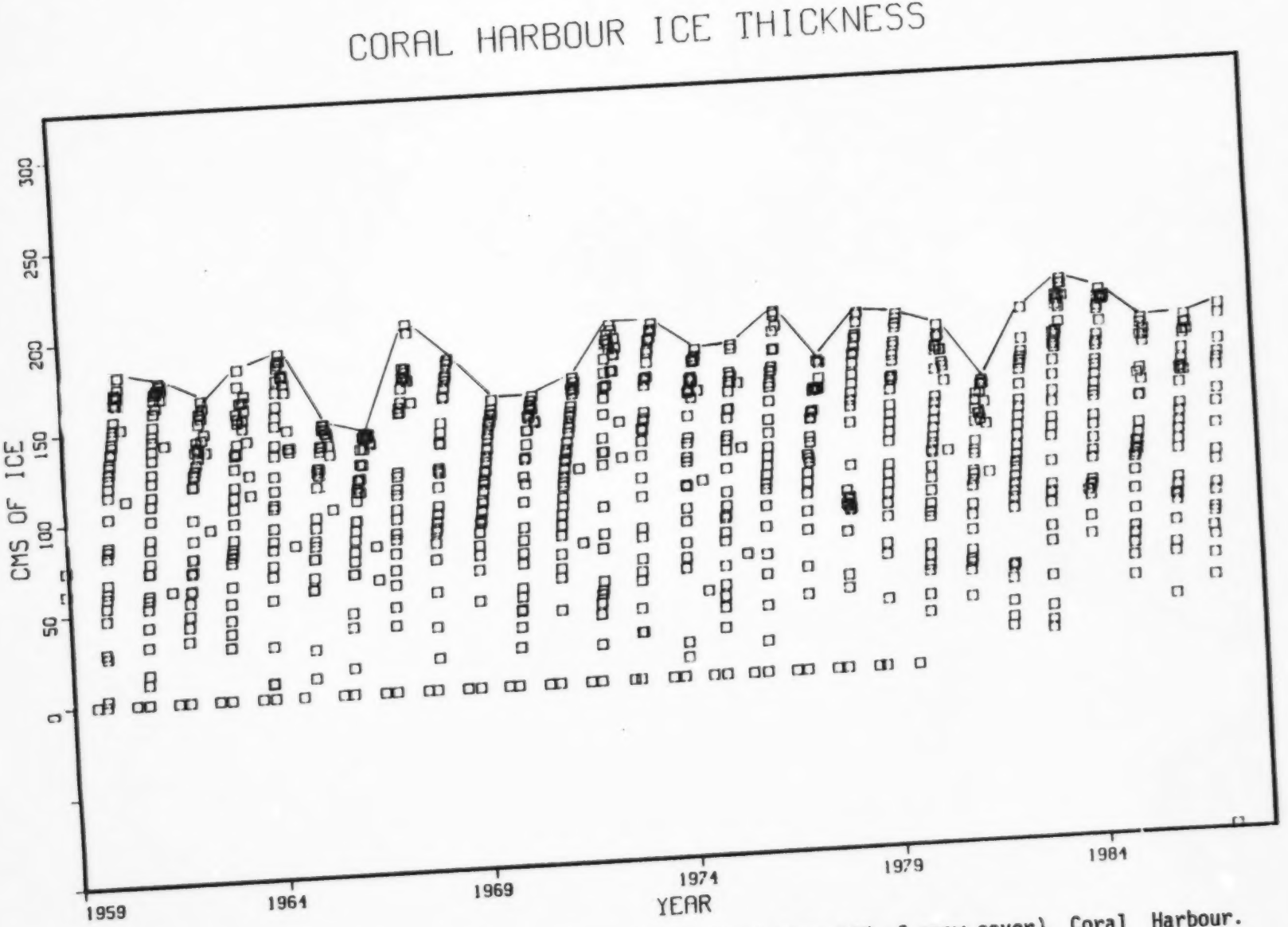

Figure 7. Time series plot of ice thickness observations (including 10% of snow cover), Coral Harbour.

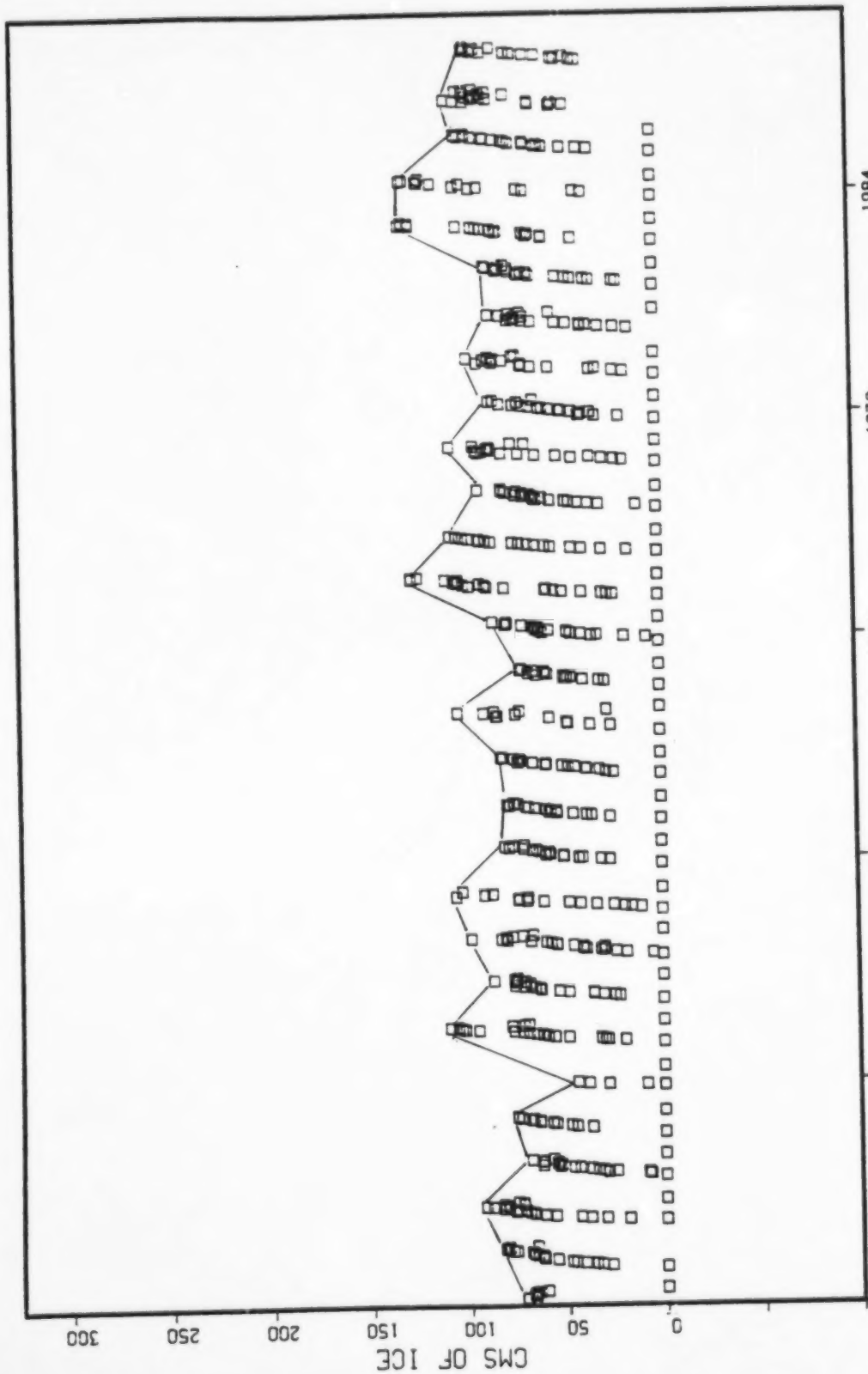

Figure 8. Time series plot of ice thickness observations (including 10% of snow cover), Moosonee.

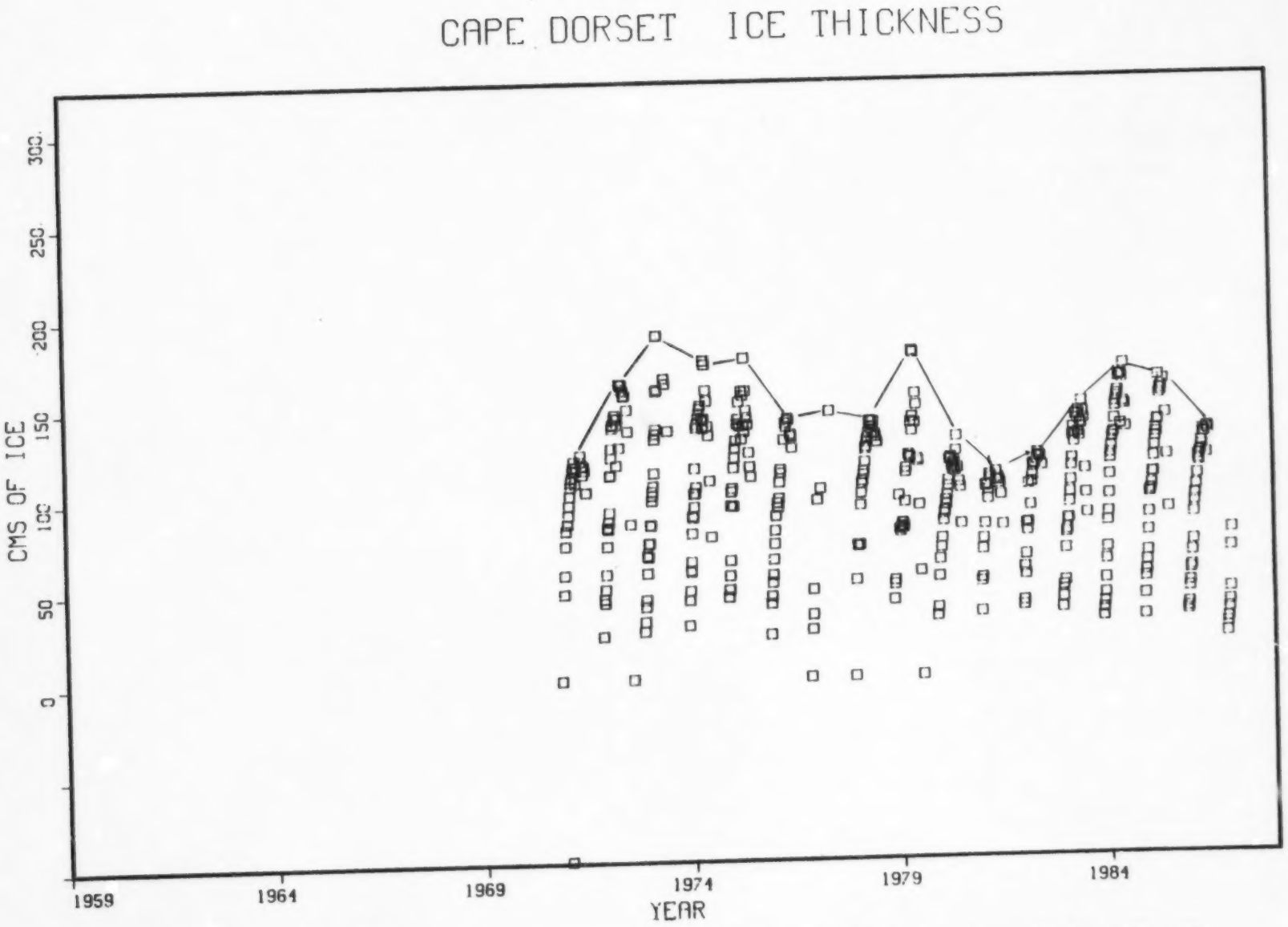

Figure 9. Time series plot of ice thickness observations (including 10% of snow cover), Cape Dorset.

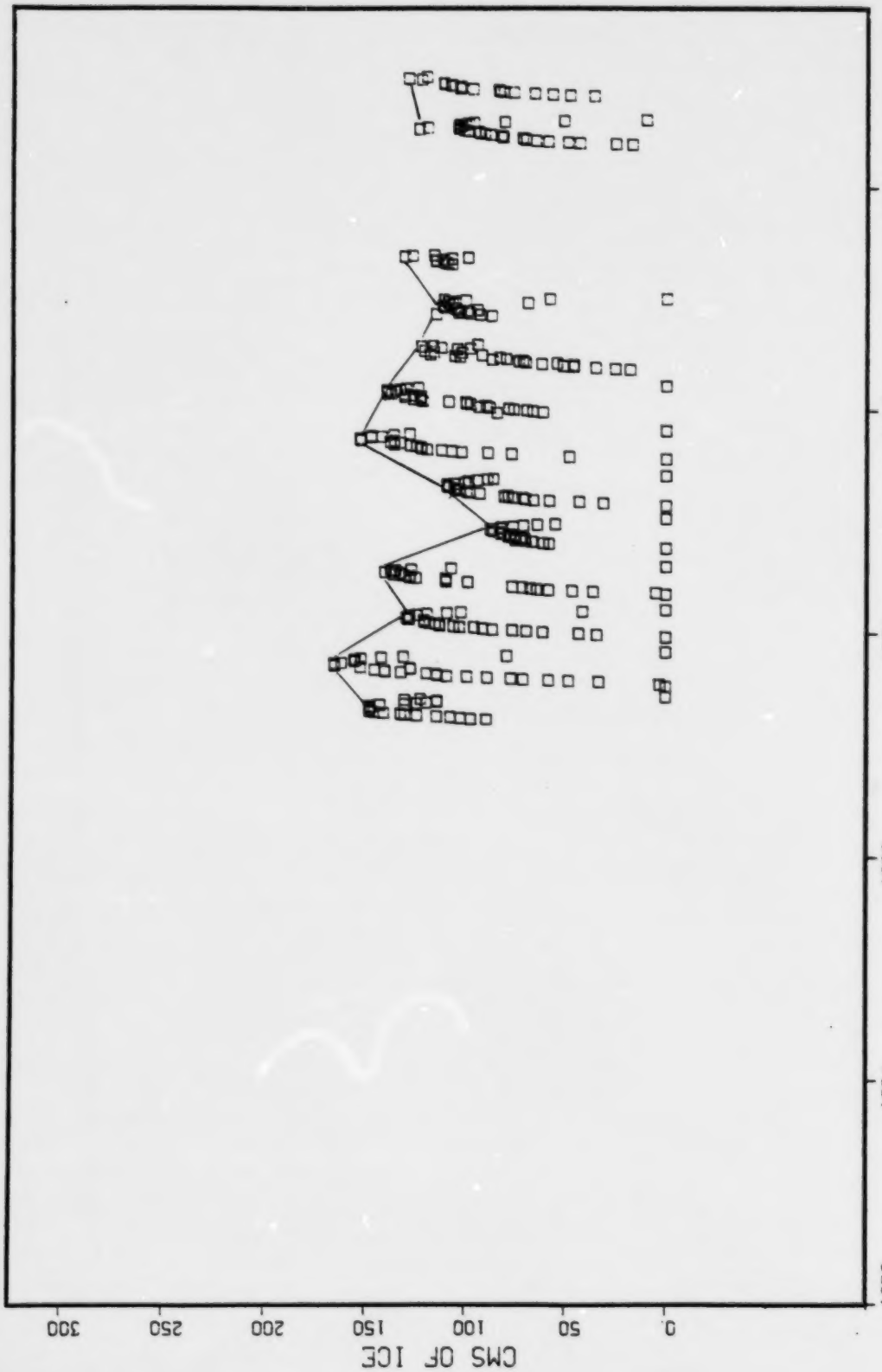

Figure 10. Time series plot of ice thickness observations (including 10% of snow cover), Koartak.

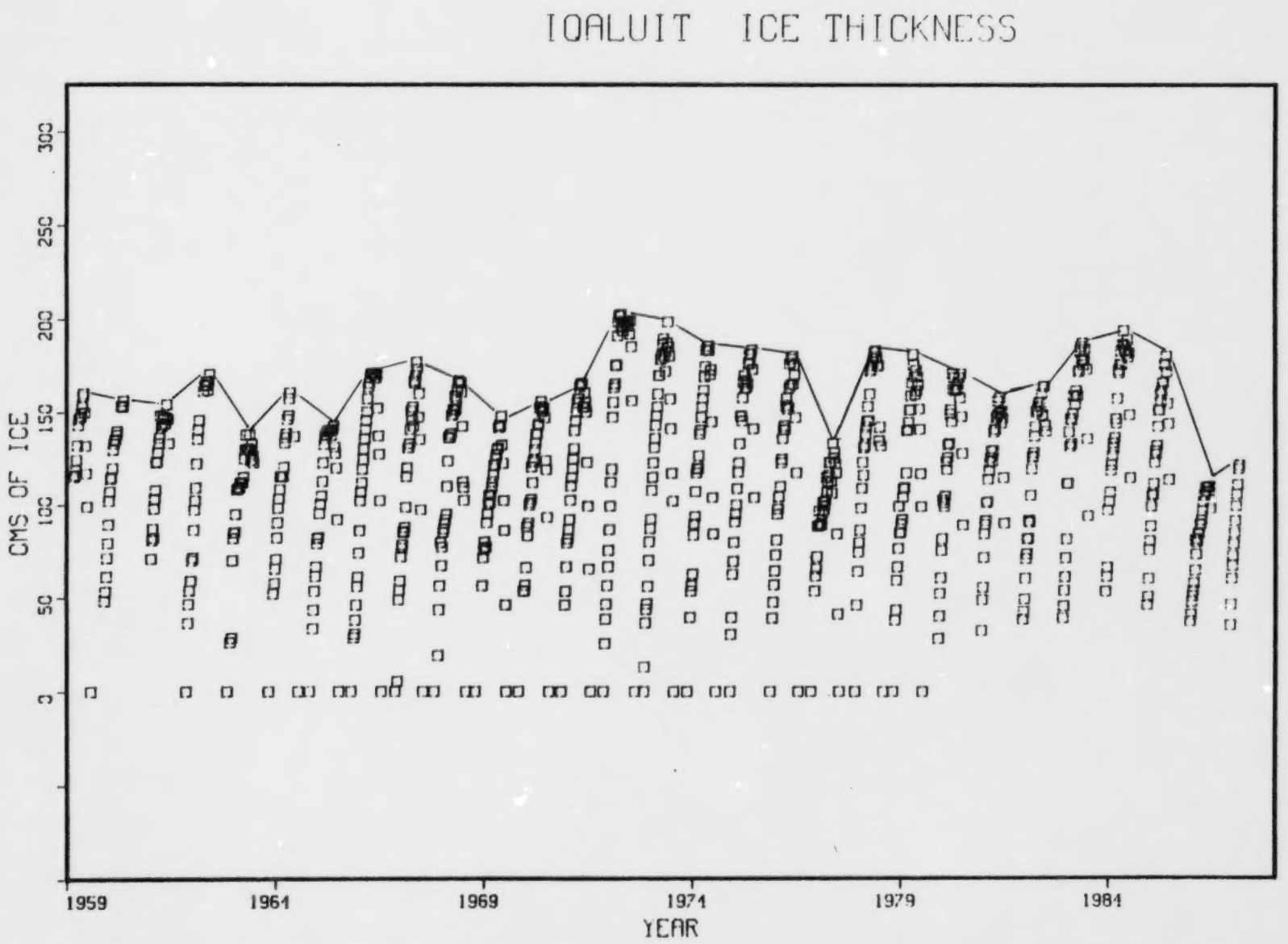

Figure 11. Time series plot of ice series thickness observations (including 10% of snow cover), Iqaluit.

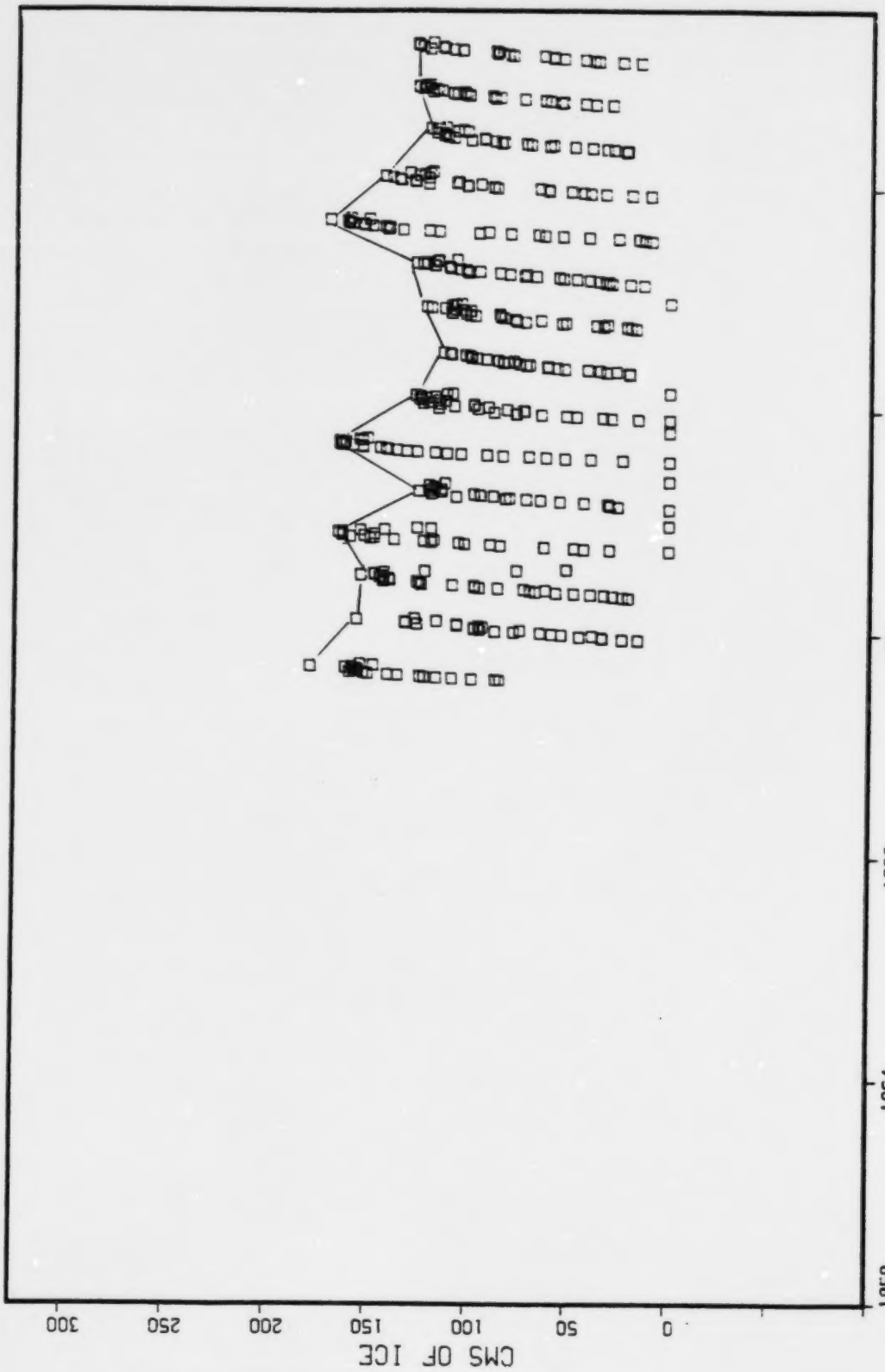

Figure 12. Time series plot of ice thickness observations (including 10% of snow cover), Kumjjuaq.

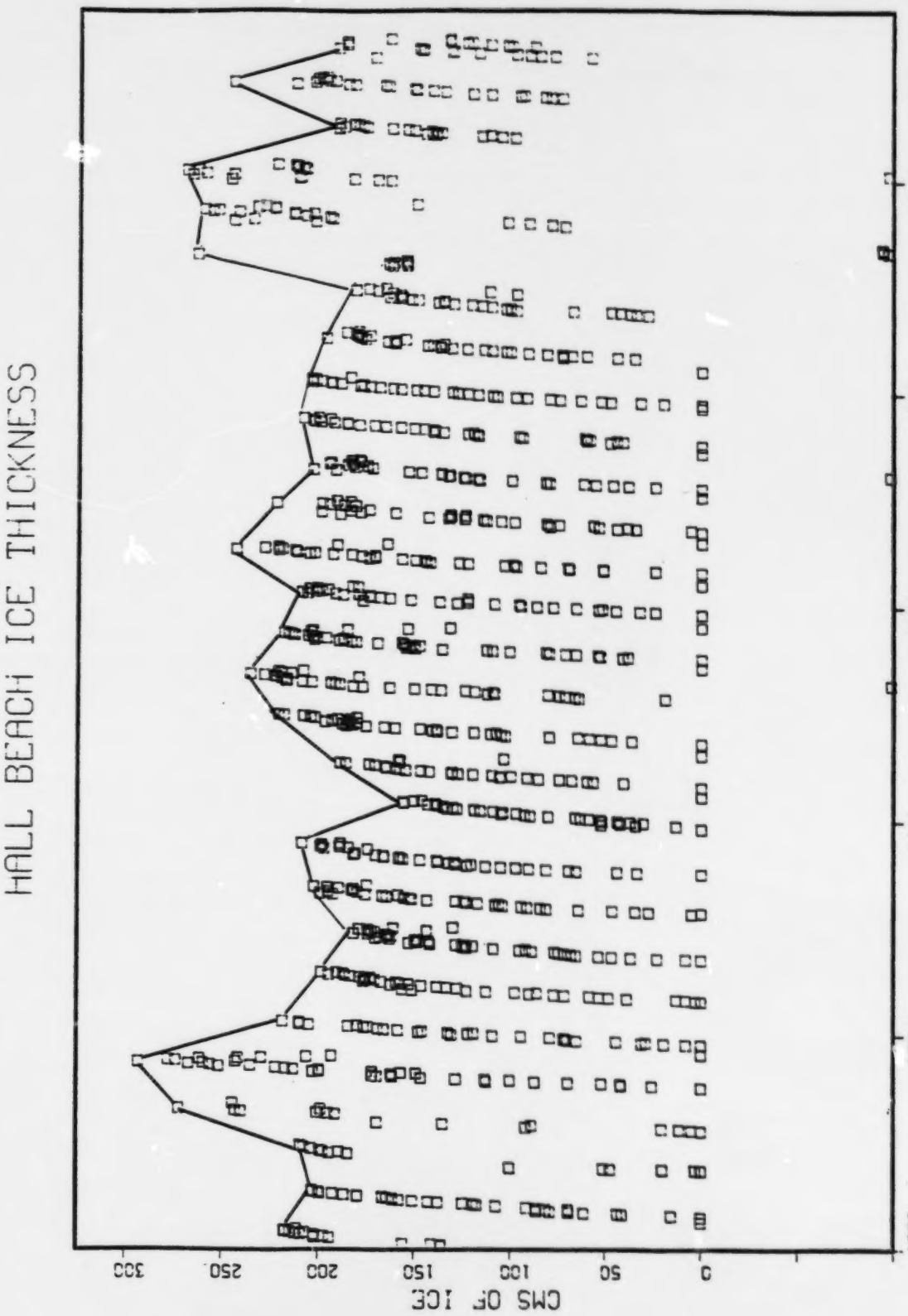

Figure 13 Time series plot of ice thickness observations (including 10% of snow cover), Hall Beach.

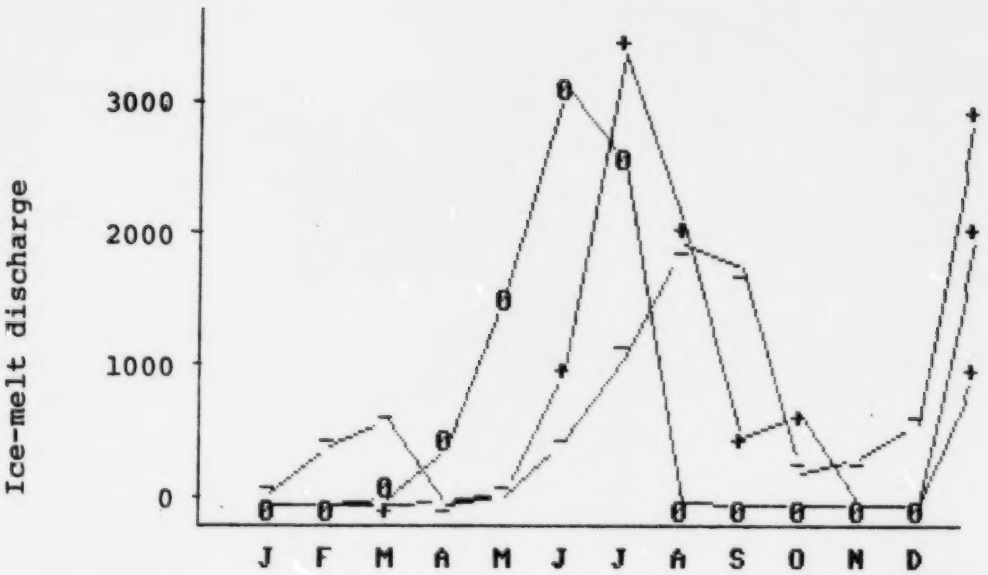

Figure 14. Long-term monthly average ice-melt discharge. Units are 100 m^3/s. Zero-drift scenario is indicated by 0--0; base drift by - -- -; and fast drift by +--+.

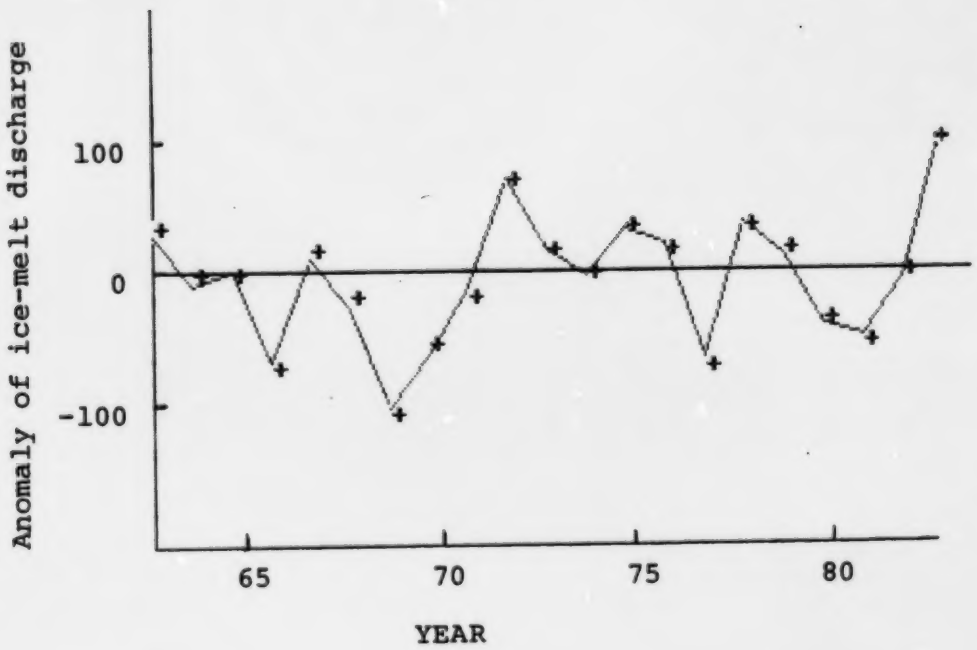

Figure 15. Annual ice-melt discharge, expressed as the anomaly of average monthly discharge and proportional to total ice volume anomaly. Units are 100 m^3/s.

Table 1. Period of Record for Selected Ice Thickness Monitoring Stations

STATION	PERIOD OF RECORD (years)										
	63	65	67	69	71	73	75	77	79	81	83
Chesterfield Inlet	**********										
Churchill	**********										
Kumjjuarapik						**********					
Inukjouac	**********										
Coral Harbour	**********										
Moosonee	**********										
Cape Dorset					**********						
Koartaq						**********					
Iqaluit	**********										
Kumjjuaq						**********					
Hall Beach	**********										

Table 2. Area and Time Lag Estimates Used in Synthesizing an Ice-melt Discharge Signal

REGION	STATION	AREA (10^5 km^2)	HUDSON STRAIT TIME LAG (months)		
			Base	Fast	Zero
NW Hudson Bay	Chesterfield Inlet	1.625	8	3	0
SW Hudson Bay	Churchill	1.557	6	2	0
SE Hudson Bay	Kumjjuarapik	1.746	4	2	0
E Hudson Bay	Inukjouac	1.447	2	1	0
NE Hudson Bay	Coral Harbour	1.098	1	1	0
James Bay	Moosonee	0.670	6	3	0
Hudson Strait	Cape Dorset				
Hudson Strait	Koartaq	1.780	0	0	0
Hudson Strait	Iqaluit				
Ungava Bay	Kumjjuaq				
Foxe Basin	Hall Beach	1.780	2	1	0

Table 3. Monthly Ice-Melt Discharges for NW Hudson Bay (units are 100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	0	393	903	0	0	0	0	0	108
4	0	0	0	0	0	356	921	0	0	0	0	0	106
5	0	0	0	0	31	412	731	0	0	0	0	0	98
6	0	0	0	0	129	184	719	0	0	0	0	0	86
7	0	0	0	0	0	326	928	0	0	0	0	0	105
8	0	0	0	0	55	74	872	0	0	0	0	0	83
9	0	0	0	0	12	430	670	0	0	0	0	0	93
70	0	0	0	0	49	989	0	0	0	0	0	0	87
1	0	0	0	0	0	332	762	0	0	0	0	0	91
2	0	0	0	0	0	123	1087	0	0	0	0	0	101
3	0	0	0	0	74	1192	0	0	0	0	0	0	106
4	0	0	0	0	141	1124	0	0	0	0	0	0	105
5	0	0	0	209	135	117	928	0	0	0	0	0	116
6	0	0	0	0	43	6	1167	0	0	0	0	0	101
7	0	0	0	0	43	1081	0	0	0	0	0	0	94
8	0	0	0	0	0	362	774	0	0	0	0	0	95
9	0	0	0	0	18	541	799	0	0	0	0	0	113
80	0	0	0	0	49	350	805	0	0	0	0	0	100
1	0	0	0	0	12	356	743	0	0	0	0	0	93
2	0	0	0	0	12	399	835	0	0	0	0	0	104
3	0	0	0	0	12	418	872	0	0	0	0	0	109
Avg.	0	0	0	10	39	455	691	0	0	0	0	0	100

Table 4. Monthly Ice-Melt Discharges for SW Hudson Bay (100 m3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	0	889	0	0	0	0	0	0	74
4	0	0	0	0	153	718	0	0	0	0	0	0	73
5	0	0	0	0	141	1024	0	0	0	0	0	0	97
6	0	0	0	65	188	765	0	0	0	0	0	0	85
7	0	0	0	6	112	877	0	0	0	0	0	0	83
8	0	0	0	18	247	547	0	0	0	0	0	0	68
9	0	0	0	0	147	906	0	0	0	0	0	0	88
70	0	94	88	171	341	359	0	0	0	0	0	0	88
1	0	0	0	0	77	983	0	0	0	0	0	0	88
2	0	0	0	24	41	759	330	0	0	0	0	0	96
3	0	0	0	124	506	506	0	0	0	0	0	0	95
4	0	0	0	12	388	730	0	0	0	0	0	0	94
5	0	0	0	41	94	335	471	0	0	0	0	0	78
6	0	0	0	212	465	541	0	0	0	0	0	0	102
7	0	0	12	118	830	0	0	0	0	0	0	0	80
8	0	0	0	0	200	800	0	0	0	0	0	0	83
9	0	0	0	0	271	800	0	0	0	0	0	0	89
80	0	0	35	724	141	0	0	0	0	0	0	0	75
1	0	0	0	24	312	506	0	0	0	0	0	0	70
2	0	0	0	71	1018	0	0	0	0	0	0	0	91
3	0	0	0	0	135	942	0	0	0	0	0	0	90
Avg	0	4	6	77	277	618	38	0	0	0	0	0	85

Table 5. Monthly Ice-Melt Discharge for SE Hudson Bay (100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	112	911	0	0	0	0	0	0	0	85
4	0	0	0	119	871	0	0	0	0	0	0	0	83
5	0	0	0	99	970	0	0	0	0	0	0	0	89
6	0	0	0	92	851	0	0	0	0	0	0	0	79
7	0	0	0	112	931	0	0	0	0	0	0	0	87
8	0	0	0	112	924	0	0	0	0	0	0	0	86
9	0	0	0	99	779	0	0	0	0	0	0	0	73
70	0	0	0	112	832	0	0	0	0	0	0	0	79
1	0	0	0	139	871	0	0	0	0	0	0	0	84
2	0	0	0	132	957	0	0	0	0	0	0	0	91
3	0	0	0	0	904	0	0	0	0	0	0	0	75
4	0	0	0	112	898	86	0	0	0	0	0	0	91
5	0	0	0	224	792	0	0	0	0	0	0	0	85
6	0	0	0	337	488	33	0	0	0	0	0	0	72
7	0	0	20	257	469	0	0	0	0	0	0	0	62
8	0	0	0	224	1016	0	0	0	0	0	0	0	103
9	0	0	0	251	700	0	0	0	0	0	0	0	79
80	0	0	26	191	607	0	0	0	0	0	0	0	69
1	0	0	0	66	878	0	0	0	0	0	0	0	79
2	0	0	0	46	779	0	0	0	0	0	0	0	69
3	0	0	0	238	1214	0	0	0	0	0	0	0	121
Avg	0	0	2	146	840	6	0	0	0	0	0	0	83

Table 6. Monthly Ice-Melt Discharges for E Hudson Bay (100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	120	1253	0	0	0	0	0	0	114
4	0	0	0	0	88	1198	0	0	0	0	0	0	107
5	0	0	0	0	0	1510	0	0	0	0	0	0	126
6	0	0	0	0	366	788	0	0	0	0	0	0	96
7	0	0	0	0	109	1324	0	0	0	0	0	0	119
8	0	0	0	0	208	1203	0	0	0	0	0	0	118
9	0	0	0	0	0	793	170	0	0	0	0	0	80
70	0	0	0	0	71	1078	0	0	0	0	0	0	96
1	0	0	93	164	109	968	0	0	0	0	0	0	111
2	0	0	0	0	88	738	733	0	0	0	0	0	130
3	0	0	0	33	645	498	0	0	0	0	0	0	98
4	0	0	0	0	656	356	0	0	0	0	0	0	84
5	0	0	0	164	394	640	0	0	0	0	0	0	100
6	0	0	0	60	503	810	0	0	0	0	0	0	114
7	0	0	0	33	230	974	0	0	0	0	0	0	103
8	0	0	0	0	432	1045	0	0	0	0	0	0	123
9	0	0	0	0	470	820	0	0	0	0	0	0	108
80	0	0	230	82	476	509	0	0	0	0	0	0	108
1	0	0	0	0	399	1138	0	0	0	0	0	0	128
2	0	0	0	0	263	749	0	0	0	0	0	0	84
3	0	0	0	0	405	990	0	0	0	0	0	0	116
Avg	0	0	15	26	287	923	43	0	0	0	0	0	108

Table 7. Monthly Ice-Melt Discharges for NE Hudson Bay (100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	33	50	174	498	0	0	0	0	0	63
4	0	0	0	8	75	137	564	0	0	0	0	0	65
5	0	0	0	12	8	328	270	0	0	0	0	0	52
6	0	0	0	0	4	299	291	0	0	0	0	0	50
7	0	0	0	0	8	166	544	0	0	0	0	0	60
8	0	0	0	0	0	519	232	0	0	0	0	0	63
9	0	0	0	0	0	112	511	0	0	0	0	0	52
70	0	0	0	0	0	394	266	0	0	0	0	0	55
1	0	0	0	0	0	332	365	0	0	0	0	0	58
2	0	0	0	0	0	37	764	0	0	0	0	0	67
3	0	0	0	0	12	241	556	0	0	0	0	0	67
4	0	0	0	0	0	598	149	0	0	0	0	0	62
5	0	0	0	8	66	677	0	0	0	0	0	0	63
6	0	0	0	0	33	253	535	0	0	0	0	0	68
7	0	0	0	0	0	208	494	0	0	0	0	0	59
8	0	0	0	0	0	141	668	0	0	0	0	0	67
9	0	0	0	0	21	257	523	0	0	0	0	0	67
80	0	0	0	0	58	291	423	0	0	0	0	0	64
1	0	0	0	0	21	419	199	0	0	0	0	0	53
2	0	0	0	0	0	237	564	0	0	0	0	0	67
3	0	0	0	0	12	191	660	0	0	0	0	0	72
Avg	0	0	0	3	18	286	432	0	0	0	0	0	62
			739		6011								
660													

Table 8. Monthly Ice-Melt Discharges for James Bay (100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	35	137	13	0	0	0	0	0	0	0	15
4	0	0	8	231	0	0	0	0	0	0	0	0	20
5	0	0	71	134	71	0	0	0	0	0	0	0	23
6	0	0	0	96	124	0	0	0	0	0	0	0	18
7	0	0	56	91	101	0	0	0	0	0	0	0	21
8	0	0	23	243	0	0	0	0	0	0	0	0	22
9	0	0	0	111	91	0	0	0	0	0	0	0	17
70	0	0	23	0	177	0	0	0	0	0	0	0	17
1	0	0	0	175	33	0	0	0	0	0	0	0	17
2	0	0	0	195	66	0	0	0	0	0	0	0	17
3	0	0	3	177	0	0	0	0	0	0	0	0	22
4	0	0	0	76	139	0	0	0	0	0	0	0	15
5	0	0	0	150	170	0	0	0	0	0	0	0	18
6	0	0	33	236	0	0	0	0	0	0	0	0	27
7	0	0	0	231	0	0	0	0	0	0	0	0	22
8	0	0	0	109	160	0	0	0	0	0	0	0	19
9	0	0	0	144	71	0	0	0	0	0	0	0	22
80	0	0	8	198	38	0	0	0	0	0	0	0	18
1	0	0	33	180	0	0	0	0	0	0	0	0	20
2	0	0	0	25	193	0	0	0	0	0	0	0	18
3	0	0	0	205	124	0	0	0	0	0	0	0	18
Avg	0	0	14	150	75	0	0	0	0	0	0	0	27
													20

Table 9. Monthly Ice-Melt Discharges for Hudson Strait Subarea (100 m^3/s)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	27	303	464	0	0	0	0	0	66
4	0	0	0	0	34	377	505	0	0	0	0	0	76
5	0	0	0	0	61	700	61	0	0	0	0	0	69
6	0	0	0	0	47	471	464	0	0	0	0	0	82
7	0	0	0	0	40	458	518	0	0	0	0	0	85
8	0	0	0	0	13	209	727	0	0	0	0	0	79
9	0	0	0	0	40	484	330	0	0	0	0	0	71
70	0	0	0	0	20	249	626	0	0	0	0	0	75
1	0	0	0	0	27	303	592	0	0	0	0	0	77
2	0	0	0	0	7	67	834	242	0	0	0	0	96
3	0	0	0	0	34	370	828	0	0	0	0	0	103
4	0	0	0	0	47	505	491	0	0	0	0	0	87
5	0	0	0	0	54	680	363	0	0	0	0	0	91
6	0	0	0	0	40	431	491	0	0	0	0	0	80
7	0	0	0	0	54	579	235	0	0	0	0	0	72
8	0	0	0	0	20	202	855	0	0	0	0	0	90
9	0	0	0	0	74	895	81	0	0	0	0	0	88
80	0	0	0	0	20	377	505	0	0	0	0	0	75
1	0	0	0	0	54	612	182	0	0	0	0	0	71
2	0	0	0	0	20	384	511	0	0	0	0	0	76
3	0	0	0	0	27	478	626	0	0	0	0	0	94
Avg.	0	0	0	0	36	435	490	12	0	0	0	0	81

Table 10. Monthly Ice-Melt Discharges for Foxe Basin (100 m^3/s).

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	121	350	1500	0	0	0	0	0	164
4	0	0	0	0	27	330	1117	0	0	0	0	0	123
5	0	0	0	0	0	310	1029	0	0	0	0	0	112
6	0	0	0	0	0	101	1103	0	0	0	0	0	100
7	0	0	0	0	0	188	1177	0	0	0	0	0	114
8	0	0	0	0	0	0	1406	0	0	0	0	0	117
9	0	0	0	0	0	168	881	0	0	0	0	0	87
70	0	0	0	0	209	747	316	0	0	0	0	0	106
1	0	0	0	0	0	0	1487	0	0	0	0	0	124
2	0	0	0	0	0	101	1487	0	0	0	0	0	132
3	0	0	0	0	0	431	1036	0	0	0	0	0	122
4	0	0	0	0	94	491	821	0	0	0	0	0	117
5	0	0	0	0	195	1440	0	0	0	0	0	0	136
6	0	0	0	0	0	377	1124	0	0	0	0	0	125
7	0	0	0	0	94	417	639	161	0	0	0	0	109
8	0	0	0	0	0	801	606	0	0	0	0	0	117
9	0	0	0	7	444	713	215	0	0	0	0	0	115
80	0	0	0	114	-27	612	626	0	0	0	0	0	110
1	0	0	0	0	0	545	680	0	0	0	0	0	102
2	0	0	0	0	34	397	1346	0	0	0	0	0	148
3	0	0	0	0	13	1090	464	0	0	0	0	0	131
Avg.	0	0	0	6	57	458	908	8	0	0	0	0	120

Table 11. Combined Ice-Melt Discharges Leaving Hudson Strait -Zero Drift. ($100\ m^3/s$)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	35	282	1242	3361	3366	0	0	0	0	0	691
4	0	0	8	358	1247	3116	3107	0	0	0	0	0	653
5	0	0	71	246	1282	4282	2091	0	0	0	0	0	664
6	0	0	0	253	1711	2608	2577	0	0	0	0	0	596
7	0	0	56	209	1302	3338	3167	0	0	0	0	0	673
8	0	0	23	373	1448	2552	3238	0	0	0	0	0	636
9	0	0	0	210	1070	2894	2561	0	0	0	0	0	561
70	0	94	111	283	1699	3816	1208	0	0	0	0	0	601
1	0	0	93	478	1117	2918	3206	0	0	0	0	0	651
2	0	0	0	351	1158	1826	5235	242	0	0	0	0	734
3	0	0	3	334	2176	3237	2420	0	0	0	0	0	681
4	0	0	0	200	2364	3889	1461	0	0	0	0	0	660
5	0	0	0	796	1900	3888	1762	0	0	0	0	0	696
6	0	0	33	844	1573	2451	3317	0	0	0	0	0	685
7	0	0	32	639	1719	3258	1369	161	0	0	0	0	598
8	0	0	0	333	1828	3351	2902	0	0	0	0	0	701
9	0	0	0	402	2069	4027	1618	0	0	0	0	0	676
80	0	0	299	1309	1363	2138	2358	0	0	0	0	0	622
1	0	0	33	269	1676	3577	1804	0	0	0	0	0	613
2	0	0	0	142	2318	2166	3257	0	0	0	0	0	657
3	0	0	0	443	1944	4108	2622	0	0	0	0	0	760
Avg.	0	4	38	417	1629	3181	2602	19	0	0	0	0	658
Std. Dev.	0	20	67	269	389	684	908	61					48
Coeff. of Var.	-	4.47	1.76	.65	.24	.21	.35	3.15					.07

Table 12. Combined Ice-Melt Discharges Leaving Hudson Strait -Base Drift ($100\ m^3/s$)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	27	303	880	2213	2447	137	13	889	576*
4	0	393	903	0	42	451	756	2211	1996	231	153	718	655
5	0	356	921	0	73	708	388	2188	2071	134	212	1024	673
6	31	412	731	0	47	475	1130	1271	1955	161	313	765	608
7	129	184	719	0	40	466	793	2168	2164	97	213	877	654
8	0	326	928	0	13	209	1453	1548	2353	261	247	547	657
9	55	74	872	0	40	484	442	1571	1830	111	238	906	552
70	12	430	670	0	20	249	1300	2296	1259	171	519	359	607
1	49	989	0	0	120	467	1034	1472	2358	175	109	983	646
2	0	332	762	0	7	67	959	1977	3177	219	107	759	697
3	330	123	1087	0	34	415	1714	1485	1943	301	506	506	704
4	74	1192	0	0	47	505	1839	1108	1718	174	528	730	660
5	141	1124	0	0	62	910	1629	2304	792	191	264	544	663
6	606	117	928	0	40	524	1248	2058	1645	481	465	541	721
7	43	6	1167	0	54	611	787	2142	1120	510	830	0	606
8	43	1081	0	0	20	202	1428	2738	1622	109	360	800	700
9	0	362	774	0	74	922	1253	2307	915	144	342	800	658
80	18	541	799	0	250	631	1271	1736	1276	922	179	0	635
1	49	350	805	0	54	633	1000	1948	1590	203	312	506	621
2	12	356	743	0	20	384	1044	1757	2124	96	1211	0	646
3	12	399	835	0	27	490	1235	2978	1679	205	260	942	755
Avg.	76	436	650	0	53	481	1123	1975	1811	240	351	628	652
Std. Dev.	140	352	381	0	51	209	371	454	547	187	263	309	48
Coeff. of Var.	1.8	.8	.6		.96	.44	.33	.23	.30	.78	.75	.49	.07

* 1963, being the initial year analysed, is missing long lag contributions.

Table 13. Combined Ice-Melt Discharges Leaving Hudson Strait - Fast Drift. ($100\ m^3/s$)

Year	J	F	M	A	M	J	J	A	S	O	N	D	Average
1963	0	0	0	0	60	742	3289	2900	393	903	0	0	691
4	0	0	0	0	42	692	3424	2399	356	921	0	0	653
5	0	0	0	0	73	878	3453	2425	412	731	0	0	664
6	0	0	0	0	47	999	2788	2412	184	719	0	0	596
7	0	0	0	0	40	749	3330	2699	326	928	0	0	673
8	0	0	0	0	13	569	3863	2241	74	872	0	0	636
9	0	0	0	0	40	583	2440	2571	430	670	0	0	561
70	0	0	0	94	108	834	4017	1167	989	0	0	0	601
1	0	0	0	93	191	551	3015	2868	332	762	0	0	651
2	0	0	0	0	7	310	2904	4051	452	1087	0	0	734
3	0	0	0	0	66	1154	3584	2172	1192	0	0	0	681
4	0	0	0	0	47	1379	3298	2067	1124	0	0	0	660
5	0	0	0	0	226	1601	4364	640	588	928	0	0	696
6	0	0	0	0	101	1548	3120	2277	6	1167	0	0	685
7	0	0	0	0	118	1278	3363	1176	1243	0	0	0	598
8	0	0	0	0	20	858	4166	2234	362	774	0	0	701
9	0	0	0	0	81	2081	2986	1628	541	799	0	0	676
80	0	0	0	230	278	1807	2862	1136	350	805	0	0	622
1	0	0	0	0	54	1155	3653	1397	356	743	0	0	613
2	0	0	0	0	20	797	3717	2115	399	835	0	0	657
3	0	0	0	0	27	1146	4452	2202	418	872	0	0	760
Avg.	0	0	0	20	79	1034	3433	2132	501	691	0	0	658
Std. Dev.	0	0	0	54	70	443	519	739	337	354	0	0	48
Coeff. of Var.	-	-	-	2.7	.9	.43	.15	.35	.67	.51	-	-	.07

APPENDIX

A.1 Detailed Description of Ice-Thickness Calculations

A.1.1 Chesterfield Inlet

The Chesterfield Inlet record ends at 1980 (Table 1). Maximum thickness and corresponding time were readily identified between 1963 and 1980. The mean time of open water was calculated over 16 years. The mean is 191 (in Julian days); the range is 32 days. This mean was used for 1964, 80, 81, 82, 83.

Linear interpolation was used to derive month-end melt values except for 1977,79,81,82,83 and portions of 1966,67,68,76 where the exponential decay model for ice-melt was least-squares fitted. A representative time constant (9 days, range of 8 - 12 days) was calculated from 6 years of good data sets (1964,63,65,69,71,72).

For 1981-83 maximum ice thickness and corrresponding date of occurrence was predicted by regressing maximum ice thickness from Coral Harbour data. These values together with Chesterfield Inlet's average time of open water and time constant were used in the exponential decay model to predict month-end ice thickness values.

A.1.2 Churchill

The Churchill Inlet record is continuous from 1963 to 1983 (Table 1). Maximum ice thickness and corresponding time were readily identified. The mean time of open water was calculated over 19 years. The mean is 164 (in Julian days); the range is 78 days. This mean was used for 1971,83.

Linear interpolation was used to derive month-end melt values except for 1968,70,72,73,74,75,77,78,79,80,82,83 where the exponential decay model for ice-melt was least-squares fitted. A representative time constant (12 days range of 8 - 19 days) was calculated from 5 years of good data sets (1964,66,67,69,71).

A.1.3 Kumjjuarapik (Poste de la Baleine)

The Kumjjuarapik record begins at 1973 (Table 1). Maximum ice thickness and corresponding time were readily identified between 1973 and 1983. The mean time of open water was calculated over 7 years. The mean is 147 (in Julian days); the range is 13 days. This mean was used for 1980,81,82,83.

Linear interpolation was used to derive month-end melt values.

For 1963-72, maximum ice thickness and corresponding date of occurrence were predicted by regressing maximum ice thickness and day from Inukjuac data. These values together

with Kumjjuarapik's average time of open water and time constant were used in the exponential decay model to predict month-end ice thickness values.

A representative time constant (14 days range 8 - 16 days) was calculated from 3 years of good data sets (75, 78 ,79).

A.1.4 Inukjuac

The Inukjuac record is continuous between 1963 and 1983 (Table 1). The mean maximum thickness and corresponding mean time were calculated over 20 years of data. These mean values (235,118, respectively) were used for 1964 where this data was missing. The mean time of open water was calculated over 17 years. The mean is 171 (in Julian days); the range is 33 days. This mean was used for 1980,81,82,83.

Linear interpolation was used to derive month-end melt values except for 1964 where an exponential decay model for ice-melt was least-squares fitted. A representative time constant (9 days, range of 8 - 14 days) was calculated from 5 years of good data sets (1966,67,68,69,70)

A.1.5 Coral Harbour

The Coral Harbour record is continuous from 1963 to 1983 (Table 1). Maximum ice thickness and corresponding time were readily identified. The mean time of open water was calculated over 17 years. The mean is 1961 (in Julian days); the range is 36 days. This mean was used for 1980, 81, 82, 83).

Linear interpolation was used to derive month-end melt values except for 73,76,77,78,79,82 where an exponential decay model for ice-melt was least-squares fitted. A representative time constant (14 days, range of 9 - 16 days) was calculated from 6 years of good data sets (1965,66,71,72,74,75).

A.1.6 Moosonee

The Moosonee record is continuous from 1963 to 1983 (Table 1). The mean maximum thickness and corresponding mean time were calculated for 20 years of data. These mean values (94,89, respectively) were used for 1964 where this data was missing.

Linear interpolation was used to derive month-end melt values where necessary.

A.1.7 Cape Dorset

The Cape Dorset record begins at 1971 (Table 1). Maximum ice thicknesss and correspondiing time were readily

identified between 1971 and 1983. The mean time of open water was calculated over 2 years. The mean is 201 (in Julian days); the range is 18 days. This mean was used for 11 years 1971,73,74,75,76,77,78,80,81,82,83.

A representative time constant (16 days, range of 15 - 17 days) was calculated from 2 years of good data sets (1972,79).

For 1963-70, maximum ice thickness was predicted by regressing from Iqaluit data. These values were used together with Cape Dorset's mean time of maximum thickness and mean time of open water.

A.1.8 Koartaq

The Koartaq record begins at 1972 and ends at 1982 (Table 1). Maximum ice thickness and corresponding time were readily identified between 1972 and 1982. The mean time of open water was calculated over 9 years. The mean is 199 (in Julian days); the range is 35 days. This mean was used for 1980,82.

A representative time constant (13 days, range of 9 - 23 days) was calculated from 5 years of good data sets (1972,73,74,75,77)

For 1963-82, maximum ice thickness data and corresponding date of occurrence were predicted by regressing from Iqaluit data. These values were used together with Koartaq's average time of open water.

A.1.9 Iqaluit (Frobisher Bay)

The Iqaluit record is continuous from 1963 to 1983 (Table 1). Maximum ice thickness and corresponding time were readily identified. The mean time of open water was calculated over 14 years. The mean is 199(in Julian days); the range is 40 days. This mean was used for 1963,75,80,81,82,83.

A representative time constant (13 days, range of 9 - 15 days) was calculated from 5 years of good data sets (1965,67,68,69,77).

A.1.10 Kumjjuaq (Fort Chimo)

The Kumjjuaq record begins at 1973 (Table 1). Maximum ice thickness and corresponding time were readily identified between 1973 and 1983. The mean time of open water was calculated over 5 years. The mean is 163 (in Julian days); the range is 39 days. This mean was used for 1973, 74, 75, 80, 82, 83.

A representative time constant (9 days, range of 8 - 12 days) was calculated from 6 years of good data sets (1963,64,65,69,71,72).

For 1963-72, maximum ice thickness and corresponding

date of occurrence were predicted by regressing from Iqaluit data. These values were used together with Kumjjuaq's average time of open water.

The Cape Dorset, Koartaq, Kumjjuac and Iqaluit data were merged to form a single signal for Hudson Strait. For each year the maximum ice thickness and corresponding time and time of open water for the four stations were (weighted-)averaged. The time constants for the four stations were averaged as well and these values were used in the exponential ice decay model to predict merged month-end ice thickness values for all four stations.

A.1.11 Hall Beach

The Hall Beach record is continuous from 1963 to 1983 (Table 1). Maximum ice thickness and corresponding time were readily identfied. The mean time of open water was calculated over 10 years. The mean is 198 (in Julian days); the range is 40 days. This value was used in 1964, 65, 66, 67, 68, 71, 78, 80, 81, 82, 83.

Linear interpolation was used to derive month-end ice thickness data except for 1964,82 where an exponential decay model for ice-melt was least-squares fitted. A representative time constant (12 days, range of 10-16 days) was calculated from 3 years of good data sets (1969,72,73).

Table A.1. Maximum ice thickness (augmented by 10% of snow cover), corresponding date, date of open water and representative decay time constants for each station by year.

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Chesterfield	1963	211	158	194	
Inlet	4	208	150	191**	11
	5	191	141	194	12
	6	168	126	192	
	7	204	154	193	
	8	163	138	200	
	9	181	145	194	8
	70	169	137	183	
	1	178	141	188	8
	2	197	154	202	8
	3	206	131	178	
	4	206	144	183	
	5	226	101	191	
	6	198	135	210	
	7	183	133	179	
	8	185	153	191	
	9	221	138	189	
	80	196	130	191**	
	1	181*	140*	191**	
	2	203*	142*	191**	
	3	212*	140*	191**	
Churchill	1963	151	151	164	
	4	148	122	172	16
	5	198	120	168	
	6	173	105	171	19
	7	169	118	162	8
	8	138	68	164	
	9	179	136	175	11
	70	179	49	166	
	1	180	134	164**	10
	2	196	112	185	
	3	193	82	158	
	4	192	116	163	
	5	160	101	200	
	6	207	93	158	
	7	163	77	144	
	8	170	125	169	
	9	182	127	166	
	80	153	81	122	
	1	143	72	162	
	2	185	92	151	
	3	183	147	164**	

** = mean value; * = regressed value

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Kumjjuarapik	1963	155*	104*	146*	
	4	150*	101*	146*	
	5	162*	107*	147*	
	6	143*	104*	148*	
	7	158*	105*	146*	
	8	157*	103*	147*	
	9	133*	107*	145*	
	70	143*	103*	146*	
	1	153*	94*	146*	
	2	165*	104*	145*	
	3	137	124	140	
	4	166	116	154	
	5	154	108	141	8
	6	130	99	153	
	7	113	84	143	
	8	188	105	150	16
	9	144	91	149	43
	80	125	88	147**	
	1	143	107	147**	
	2	125	92	147**	
	3	220	98	147**	
Inukjuac	1963	251	137	177	
	4	235	118	176	
	5	276	155	168	
	6	211	133	159	8
	7	262	140	173	9
	8	258	131	170	10
	9	176	157	184	14
	70	210	128	179	9
	1	244	71	177	
	2	285	133	189	
	3	215	110	165	
	4	185	137	156	
	5	219	101	164	
	6	251	100	165	
	7	226	119	169	
	8	270	118	180	
	9	236	138	164	
	80	237	81	171**	
	1	281	121	171**	
	2	185	120	171**	
	3	255	126	171**	

** = mean value; * = regressed value

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Coral Harbour	1963	182	117	206	
	4	189	117	203	
	5	149	114	183	9
	6	143	120	194	12
	7	173	119	209	
	8	181	145	194	
	9	150	151	198	
	70	159	159	189	
	1	168	155	195	16
	2	193	154	213	16
	3	195	145	196	
	4	180	158	188	11
	5	181	115	177	9
	6	198	142	196	
	7	169	162	195	
	8	195	154	203	
	9	193	138	195	
	80	186	130	196**	
	1	154	142	196**	
	2	193	155	196**	
	3	208	147	196**	
Moosonee	1963	73	67	123	
	4	94**	89**	121	
	5	109	77	130	
	6	87	98	135	
	7	98	76	145	
	8	105	54	117	
	9	80	96	133	
	70	79	72	129	
	1	82	93	124	
	2	103	98	139	
	3	71	82	119	
	4	85	109	140	
	5	126	108	126	
	6	106	86	119	
	7	91	98	120	
	8	106	90	132	
	9	85	96	128	
	80	96	88	123	
	1	84	79	119	
	2	86	113	126	
	3	130	91	125	

** = mean value

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Koartaq	1963	105*	131*	199*	
	4	118*	123*	198*	
	5	108*	132*	195*	
	6	127*	122*	197*	
	7	131*	132*	198*	
	8	123*	137*	201*	
	9	111*	137*	197*	
	70	117*	130*	200*	
	1	124*	123*	199*	
	2	148	119	211	11
	3	166	118	215	23
	4	129	131	194	11
	5	140	136	180	9
	6	87	121	211	
	7	109	112	195	16
	8	153	125	201	
	9	139	159	201	
	80	123	151	199**	
	1	112	121	181	
	2	131	156	199**	
	3	137*	138*	199*	
Cape Dorset	1963	119*	130**	201**	
	4	135*	130**	201**	
	5	123*	130**	201**	
	6	145*	130**	201**	
	7	149*	130**	201**	
	8	140*	130**	201**	
	9	127*	130**	201**	
	70	133*	130**	201**	
	1	123	134	201**	
	2	161	140	210	17
	3	188	89	201**	
	4	174	130	201**	
	5	175	120	201**	
	6	141	128	201**	
	7	145	127	201**	
	8	139	148	201**	
	9	177	131	192	15
	80	130	144	201**	
	1	110	123	201**	
	2	120	127	201**	
	3	148	154	201**	

** = mean value; * = regressed value

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Iqaluit	1963	138	137	199**	
	4	161	127	197	
	5	143	141	185	14
	6	171	119	194	
	7	177	139	195	14
	8	165	152	208	8
	9	148	151	191	15
	70	156	135	204	
	1	166	120	201	
	2	203	98	225	
	3	199	145	200	
	4	186	137	198	
	5	184	150	199**	
	6	180	143	193	
	7	134	133	186	13
	8	183	140	208	
	9	182	103	186	
	80	171	159	199**	
	1	158	135	199**	
	2	165	162	199**	
	3	185	154	199**	
Kumjjuaq	1963	111*	109*	170*	
	4	129*	103*	167*	
	5	115*	110*	147*	
	6	141*	103*	162*	
	7	146*	110*	164*	
	8	135*	114*	185*	
	9	120*	114*	157*	
	70	127*	108*	179*	
	1	136*	103*	174*	
	2	170*	95*	213*	
	3	179	110	163**	
	4	156	123	163**	
	5	154	122	163**	
	6	166	110	156	10
	7	126	77	158	
	8	165	104	195	
	9	127	131	149	
	80	113	116	163**	
	1	122	128	156	10
	2	127	120	163**	
	3	171	112	163**	

** = mean value; * = regressed value

STATION	YEAR	MAXIMUM THICKNESS (cm)	DATE (Julian days)	DATE OF OPEN WATER (Julian days)	TIME CONSTANT (days)
Hall Beach	1963	293	137	202	
	4	219	122	198**	
	5	199	176	198**	
	6	179	175	198**	
	7	203	174	198**	
	8	209	181	198**	
	9	156	164	206	10
	70	189	135	196	
	1	221	183	198**	
	2	236	161	207	16
	3	218	152	189	11
	4	209	130	185	
	5	243	130	180	
	6	223	163	209	
	7	195	134	220	
	8	209	156	198**	
	9	205	117	190	
	80	197	109	198**	
	1	182	156	198**	
	2	264	106	198**	
	3	233	147	198**	